

## Hurricane and Severe Storm Sentinel (HS3) Mission

### HS3 2013-08-24,25 Flight Report: GLOBALHAWK AV-6 mission to SAL and P24L

#### Mission Scientists:

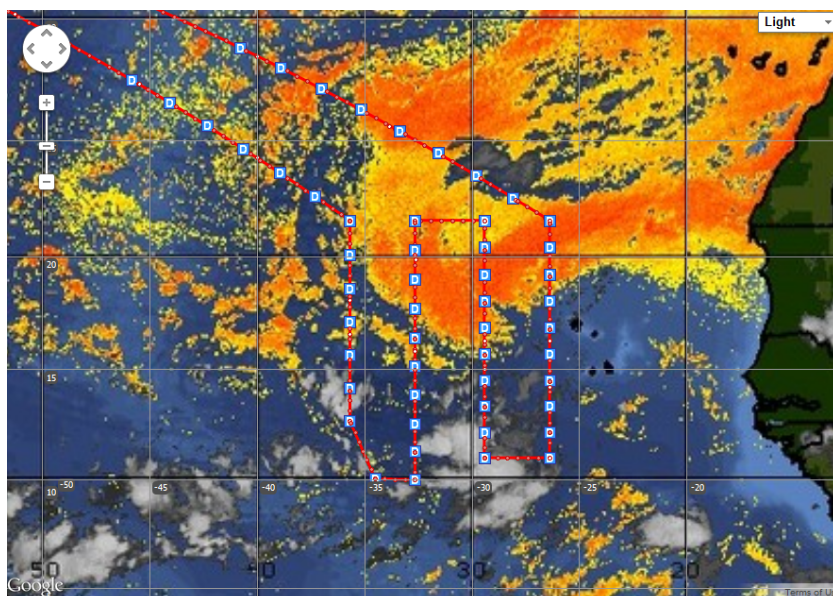
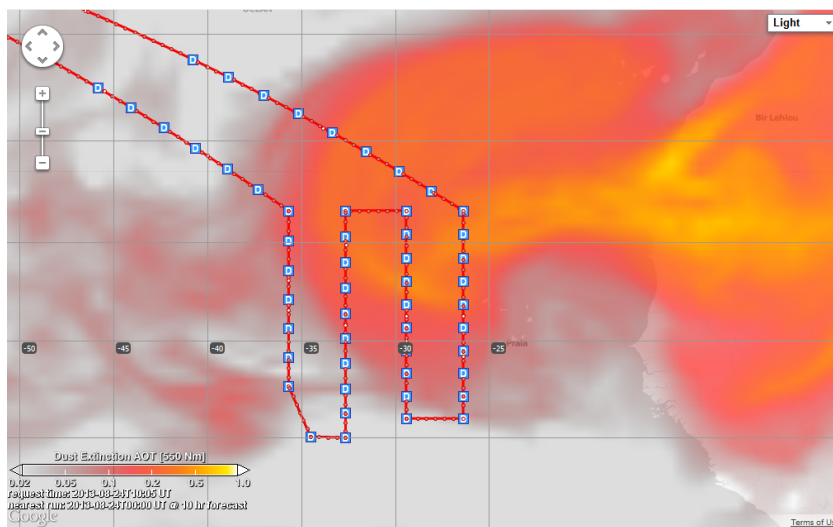
Shift 1 (0800-1700 UT): Scott Braun/Anthony Didlake

Shift 2 (1600-0100 UT): Paul Newman/ Jeff Halverson/ Pete Black

Shift 3 (0000-0900 UT): Jon Zawislak/ Amber Emory/ Steve Guimond/ Dan Cecil

Shift 4 (0800-1200 UT): Gerry Heymsfield/ Pete Black

Mission goal: Lawnmower pattern covering P24L and a major SAL outbreak to its north. The initial plan was for the lawnmower to move from east to west to sample the extent to which the SAL air is getting into P24L and to look at basic SAL structure. We realized this morning that moving through the pattern from east to west would mean that we would be moving with the wave and sampling little area with respect to the wave. We plan on reversing the order of the waypoints in order to sample a broader region within the wave.



GOES SAL product (above) for 09Z Aug 24 shows SAL air mass entering lawnmower region, about 2 hours prior to takeoff. Convection in P24L appears to be weak, focused closer to ITCZ to the south of the likely pouch.

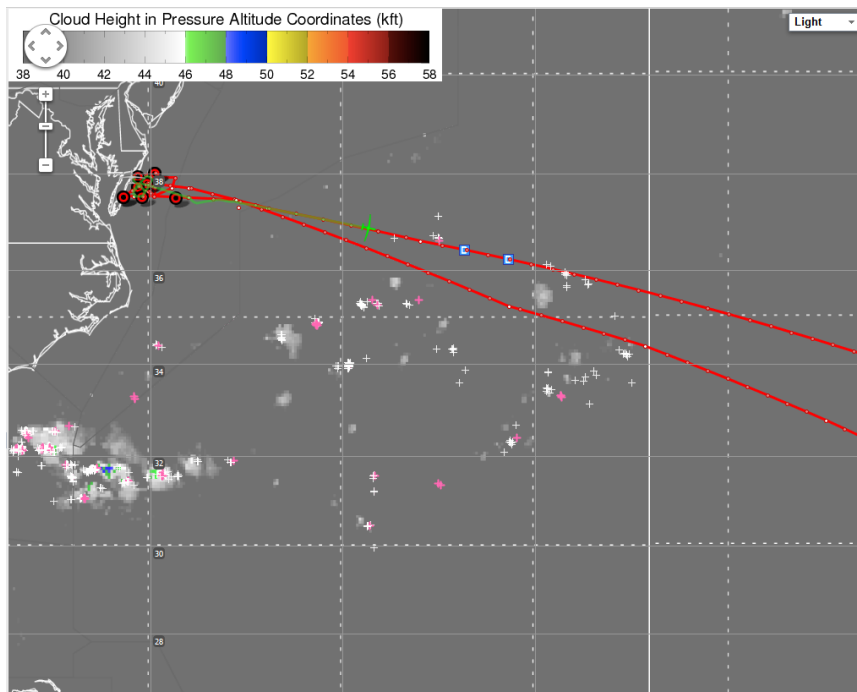
1058 UTC take off

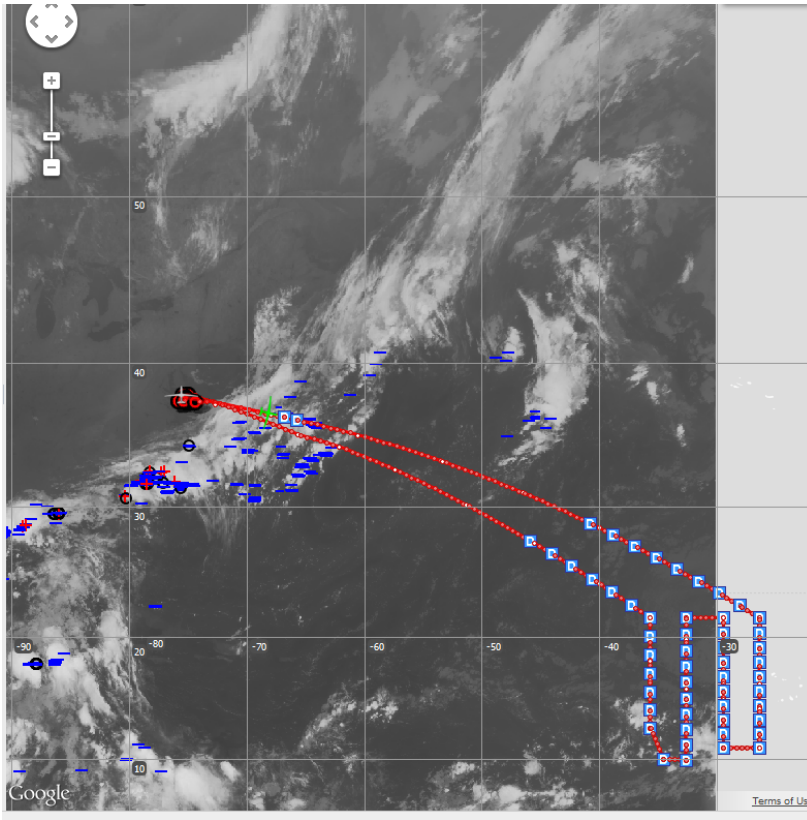
1200 Talked with P. Hall about reversing the order of the waypoints. He thinks it should not be a problem, just need to refile the flight plan. Reversing the pattern may add time to the flight, so we will need to consider options for shaving time. Some options include

- Moving the eastern two lawnmower legs westward a bit
- Cutting out a portion of the southeastern corner of the pattern
- If needed, using a zig-zag pattern between legs 2 and 3 or between 3 and 4

1214 UTC: At 53kft so CPL can start lasing again.

1224 Lightning ahead along the flight path, but cloud top heights (CTHs) are below 40kft, aircraft is at 54kft.

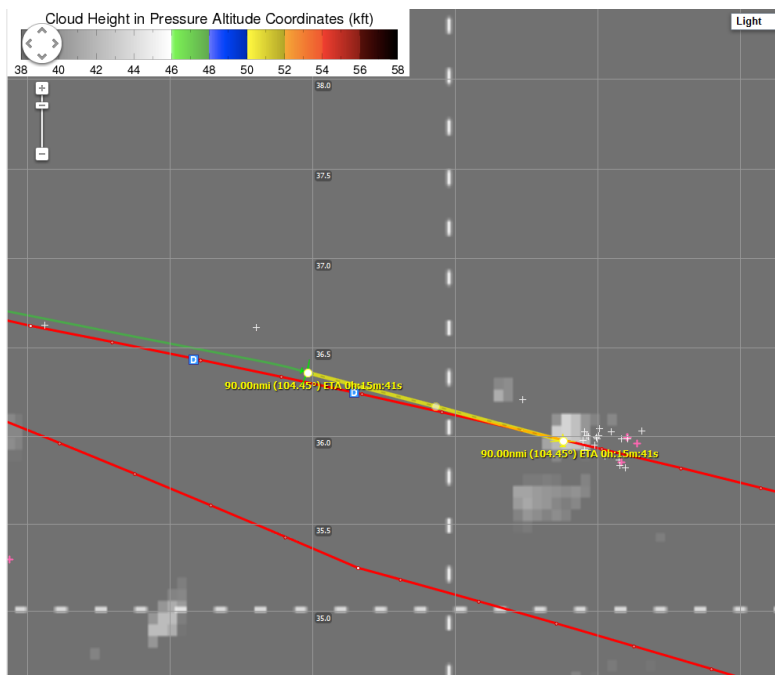




Lightning is associated with a frontal system off the east coast.

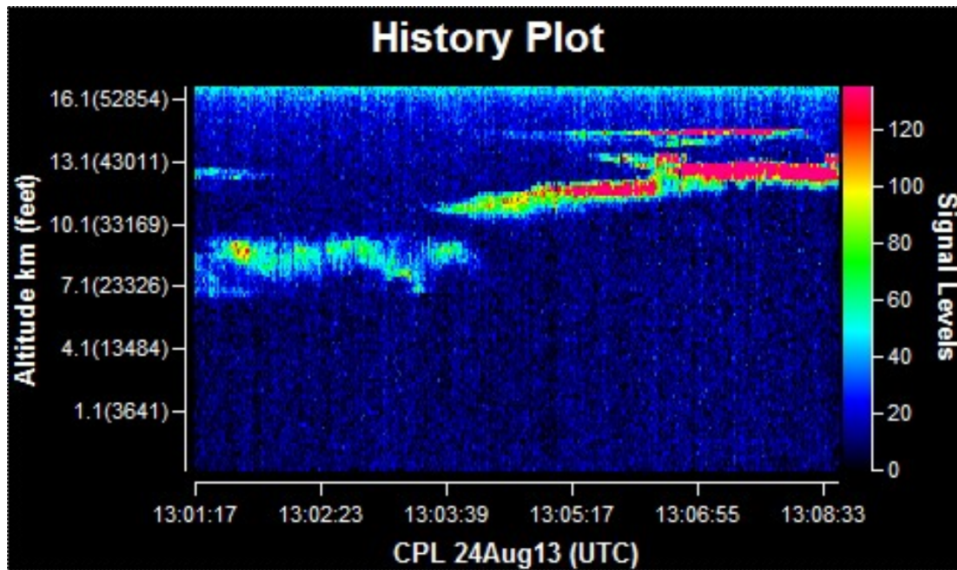
1244 First drop released. Data looks good.

1251 Seeing lightning with ~45kft tops about 15 min ahead. Flight altitude ~55 kft.



1253 Second drop released. Data looks good.

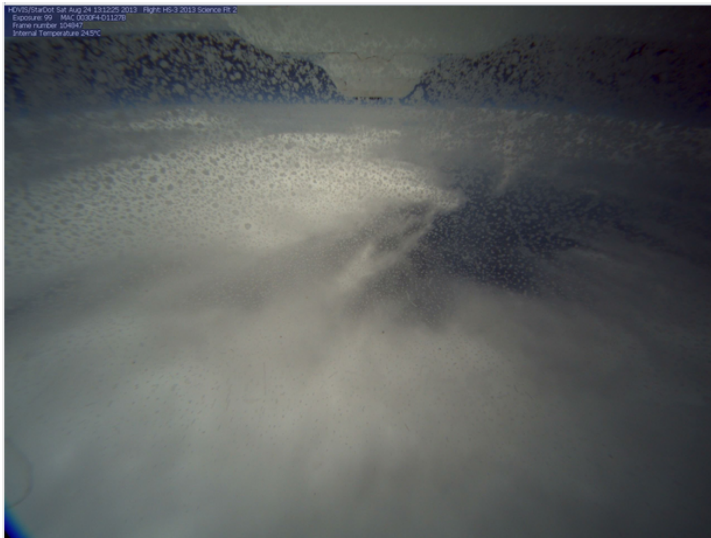
1308 Overflying convective cell. CPL image (below) shows high cloud tops near 43 kft with thin cirrus just a bit higher. CTH estimate from CIMSS in good agreement with CPL.



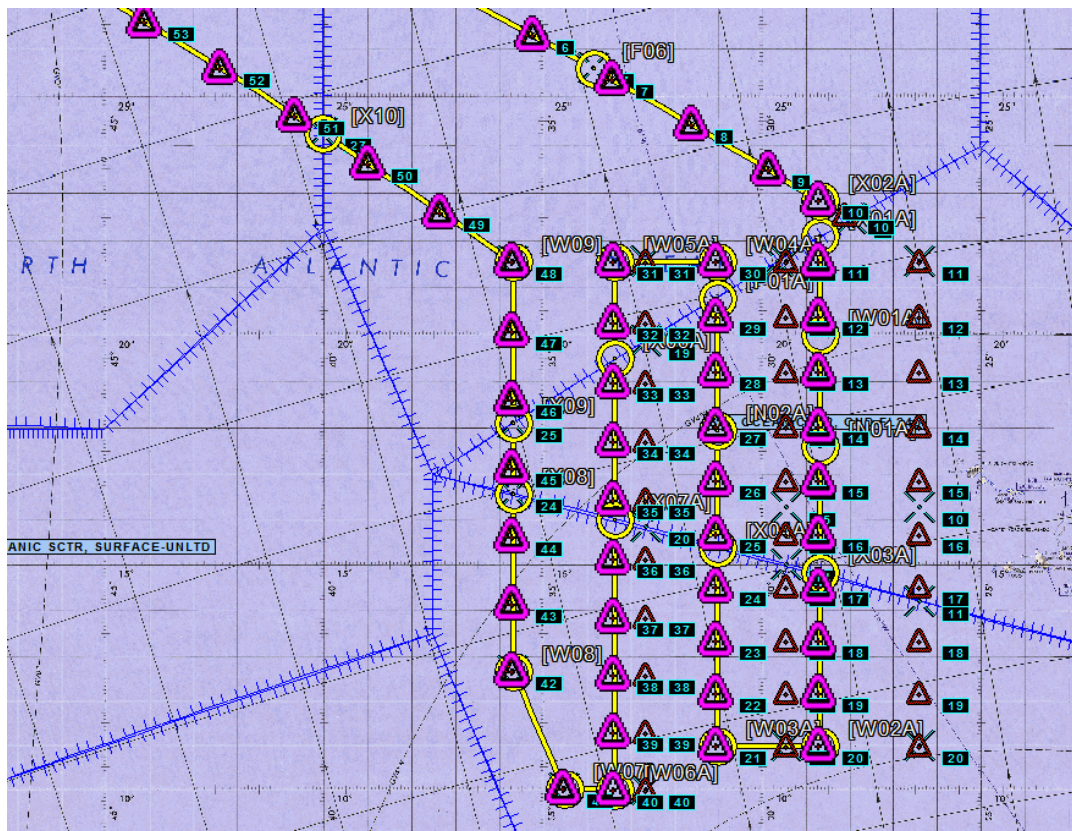
1326 Making adjustments to the flight legs. The legs are being shifted as follows:

- Waypoints W09-W07 remain the same
- Waypoints W06-W05 shifted from 32deg 40 m to 33deg 20 m
- Waypoints W04-W03 shifted from 29deg 25m to 31deg 0m
- Waypoints W02-W01 shifted from 26deg 20m to 28deg 40 m

1330 HDVIS image quality appears to be better today. Still some condensation, but D. Fratello thinks additional purging may improve it.

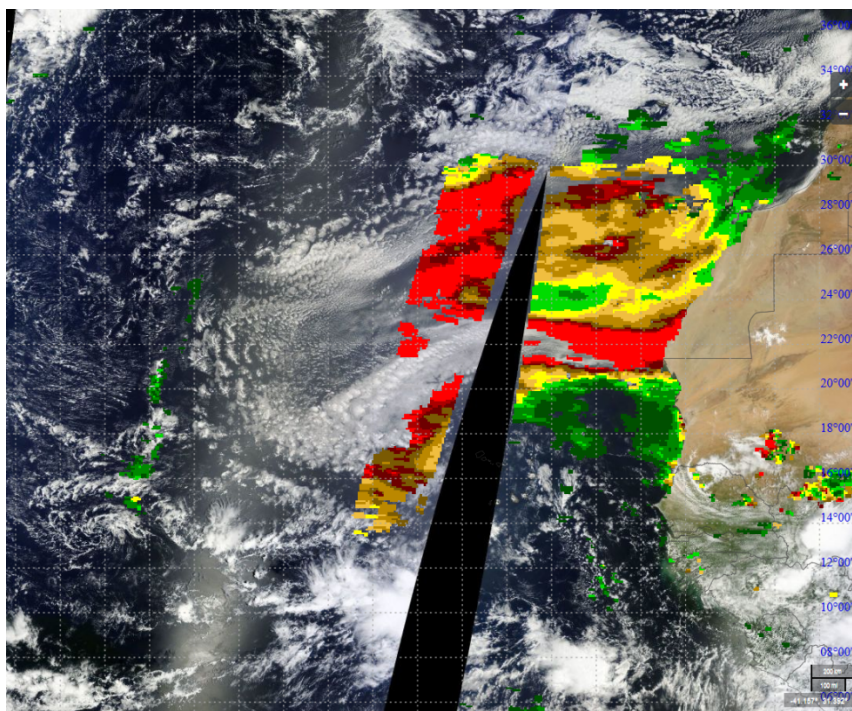


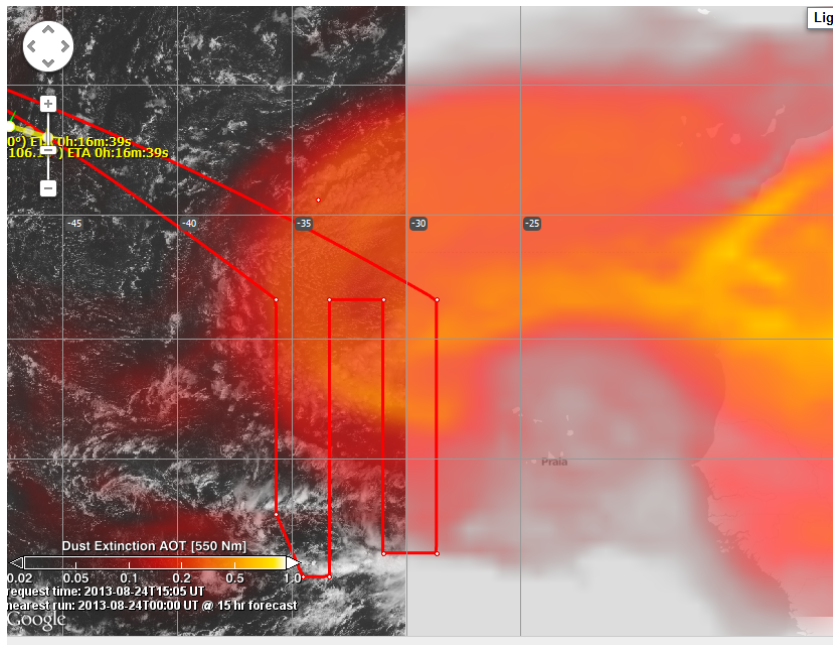
1355 GH now shifting from original track to the new track... And the long wait begins before anything interesting. Next dropsonde around 1615 UTC.



The map above shows the adjust flight plan and new drop locations.

MODIS real-time data (below) shows the dust plume in good detail. There is a prominent dust streak on the southern edge of the SAL and other high dust areas farther north. The GEOS-5 dust forecast appears to capture this structure fairly well.





The leading “head” of the dust plume is in the flight pattern. The wave axis should be in the pattern by the time the GH is there.

1617 Dropsonde #3. Good launch.

1629 No dropsonde #4 because of traffic conflict.

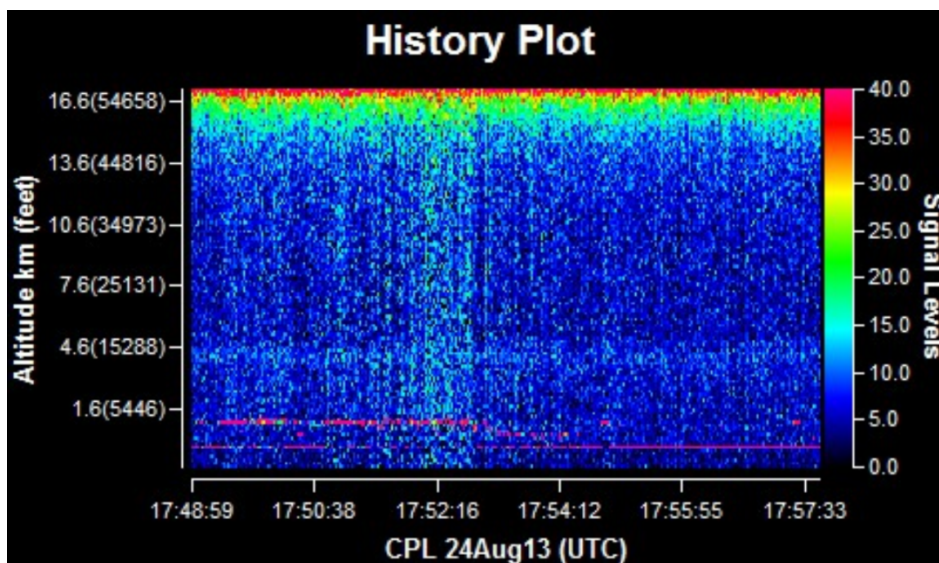
1657 Drop #5. One spare sonde available.

1717 Drop #6. Good data.

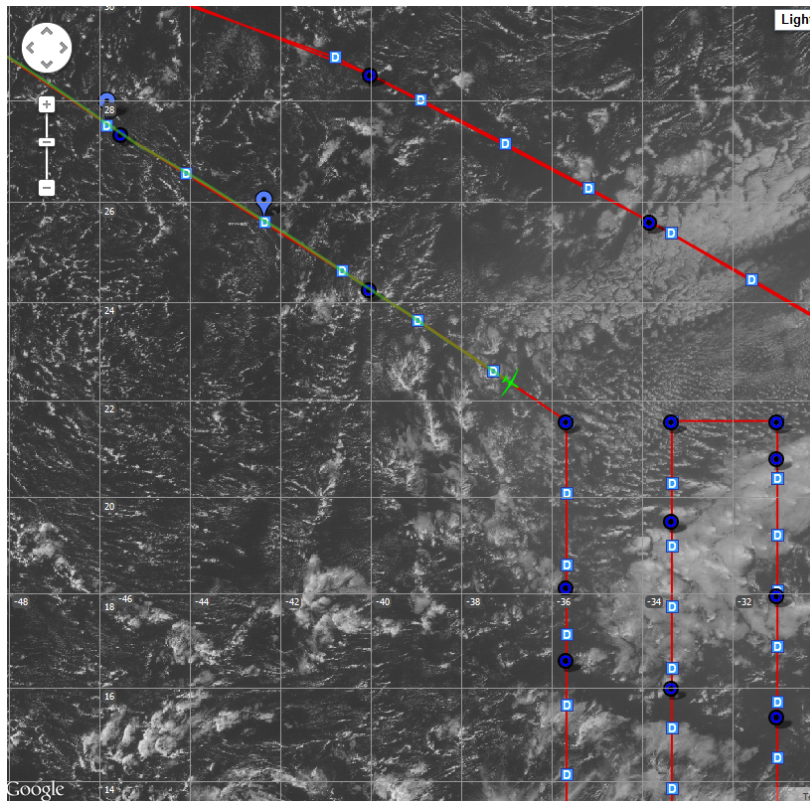
1737 Drop #7 Good data.

1757 Drop #8 Sonde released

1806 CPL shows good dust in their quick look product. See below. Note the layer just below 4.6 km.



1807 The cloud visible imagery also shows a marked difference between the “dust” region and the “clear” region.



1818 started the 1st leg of the lawnmower

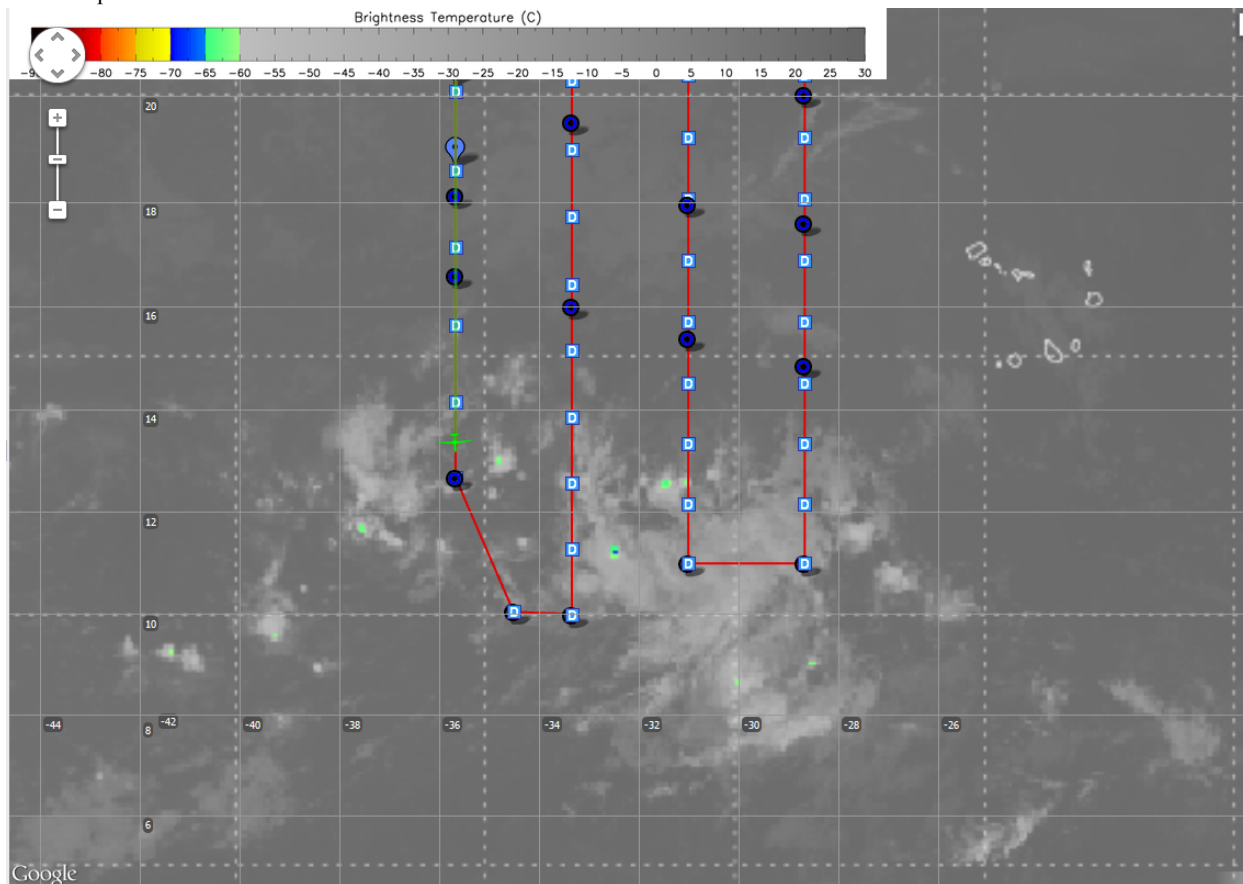
1819 Drop #9 Good drop. Still one spare sonde.

1832 Drop #10. Good drop.

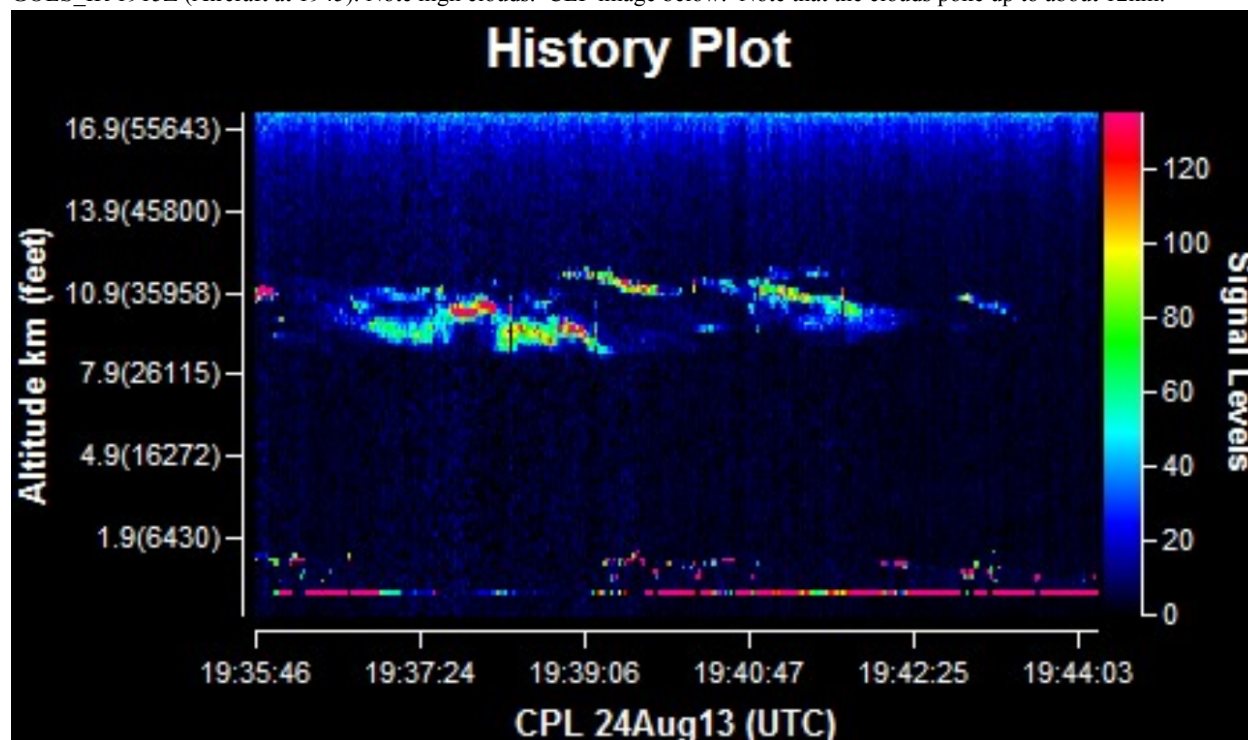
1849 Drop #11

1905 Drop #12 – fast fall

# 1921 Drop #13



GOES\_IR 1915Z (Aircraft at 1945). Note high clouds. CLP image below. Note that the clouds poke up to about 12km.



1951 Turning SSE. Nose camera shows some high cloud. Sorta evident in HDvis, but icing obscures this.

1952 Drop 14 Sonde release. Good data

2009 Drop 15 (Extra sonde) released.

2024 Drop 16, data good.

2032 Turning north onto 2<sup>nd</sup> leg. AVAPS ready to launch after wings level.

2036 Sond 17. Data good.

2041 MTS on Firefox crashed.

2049 Sonde launched, good data

2103 Sonde launched. Good data

2117 Sonde 20 launched. Good data.

2131 Sonde 21, good data

2145 Sonde 22. Good data.

2159 Sonde 23, good data.

2212 Sonde 24, good data.

2226 Sonde 25. Good data.

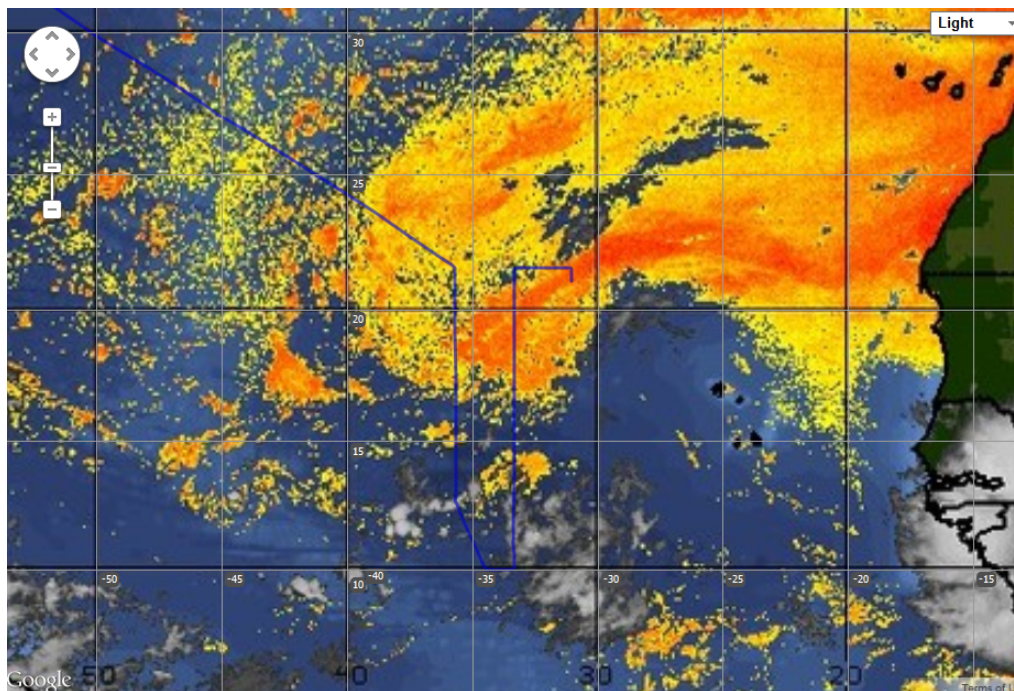
2238 Completing 2<sup>nd</sup> leg

2240 Sonde 26. Good data.

2303 Turning onto the 3<sup>rd</sup> leg. Plane is just going over 60kft after 12 hours of flying.

2304 Sonde 27. Good data.

The CIMSS SAL product shows us flying over a thick SAL layer. CPL confirms this with dust extending up to about 5 km.



2316 Sonde 28 launched. Good data.

2320 CPL shows dust starting to thin.

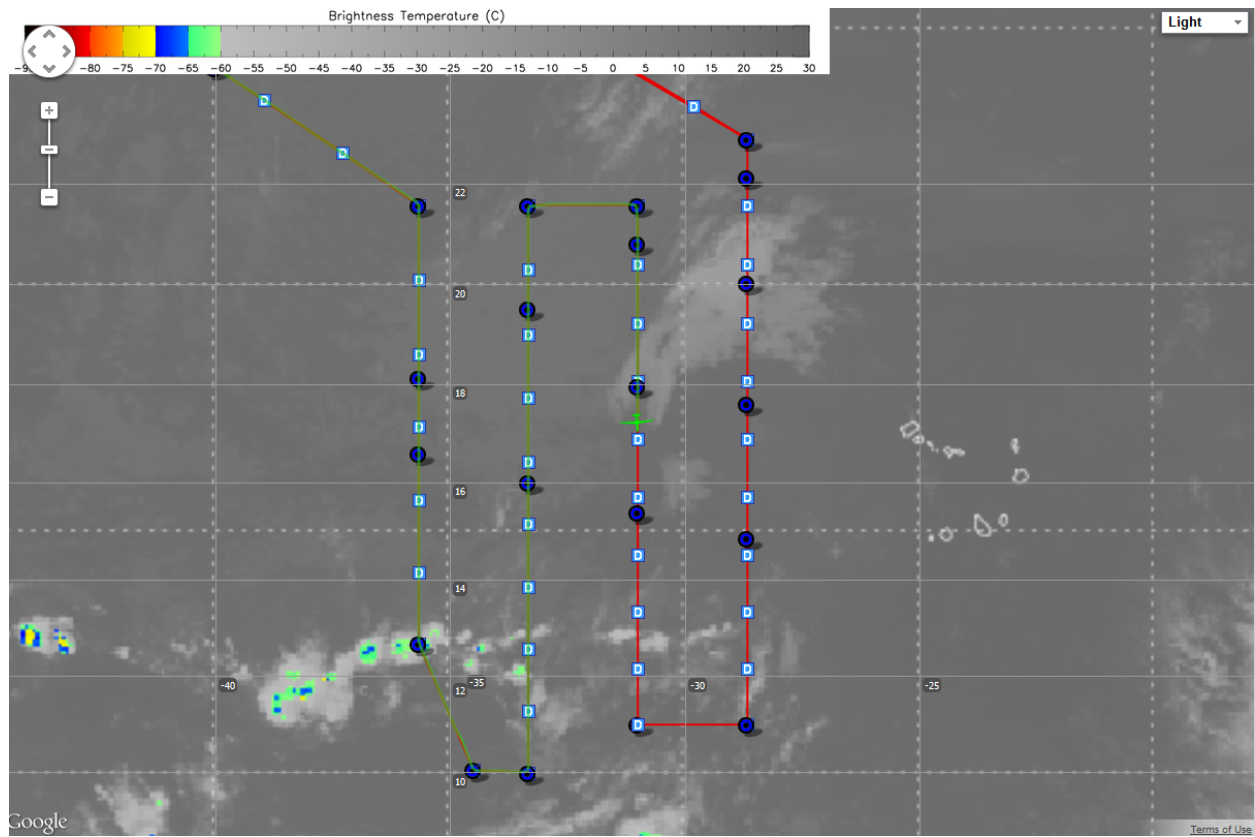
2328 Sonde 29 launched. Good data.

2341 Sonde 30. Good data.

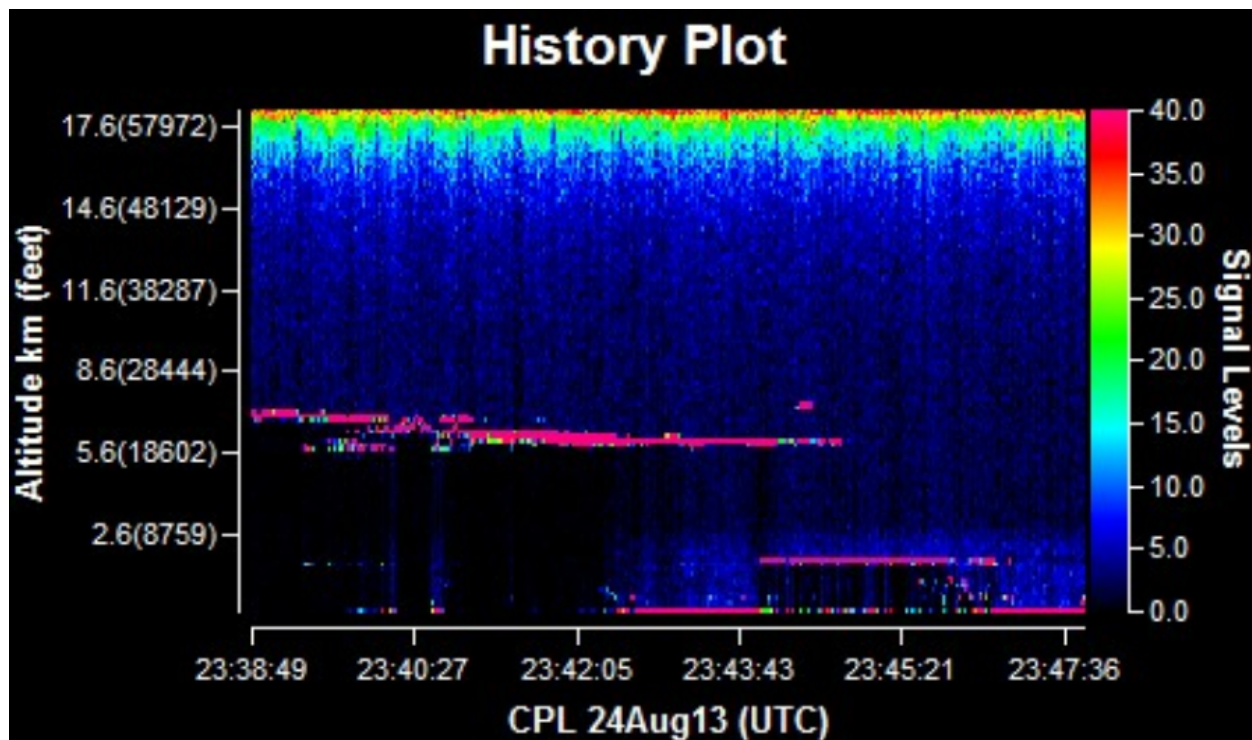
2343 Crossing out of SAL air.

2342 I think we just crossed out of the SAL. CPL shows an opaque deck at about 7km. CIMSS SAL product suggests the same.

2353 Sonde 31. Good data.



2315 IR image. Note the “cold cloud” that the plane just crossed. CPL showed this at about the same time on the southern side. See below.



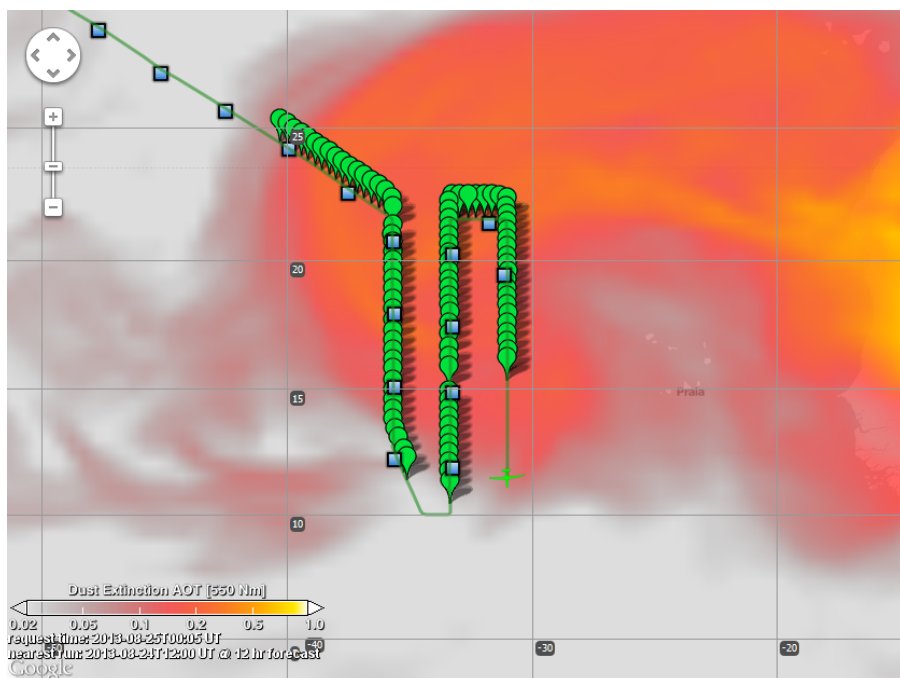
0006 Sonde 32. Good.

0019 Sonde 33. 14.47N/31.0W. Good data.

0032 Sonde 34. 13.37N/31.0W. Good data. Starting to lose Ku as we go south – not as strong as the previous legs.

0045 Sonde 35. 12.12N/-31.0W. Good data.

0050 We are approaching the end of the 3<sup>rd</sup> north-south leg. Before losing Ku, CPL was showing a very thin SAL layer at 3 km. So the forecast from GEOS-5 (below) which shows a plume reaching the southern part of the pattern seems to be verified – it just seems to be thin and small in vertical depth. Sonde at 18N appears to show the inversion to be slightly higher (825 hPa) with layer topping out at 550 hPa, compared to sounding at 21N in the meat of the SAL which showed inversion base closer to 900 hPa and a dry layer with much greater vertical depth.

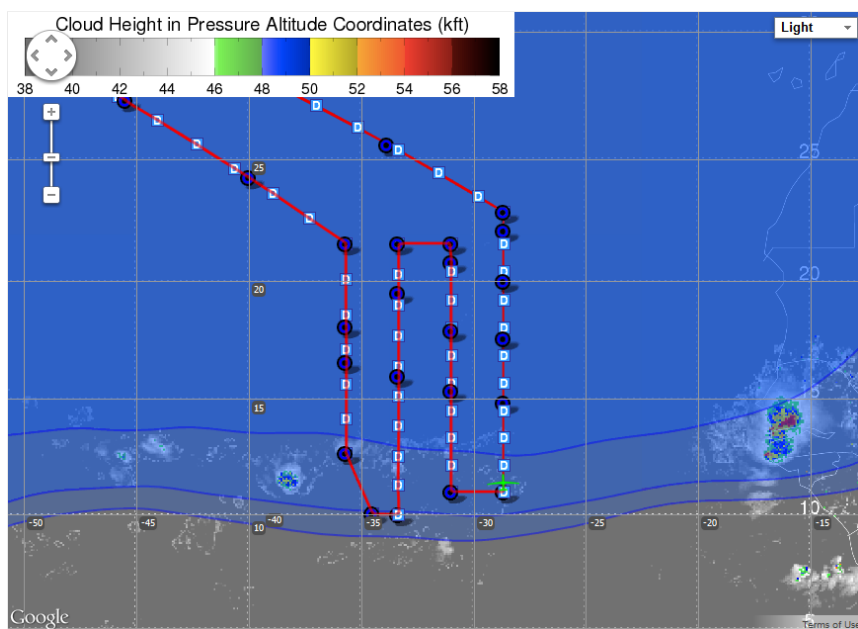


0058 Sonde 36. 11.0N/30.8W. Good data. We made the turn at original WP 'W03' and then released the sonde.

0120 According to the dust forecast, the SAL should be really thinned out on this 3<sup>rd</sup> east-west leg (southeastern-most point of the pattern). We'll have to verify this later.

0122 Turning at original WP 'W02' to north on final north-south leg.

0124 Sonde 37. 11.17N/28.5W. Good data.

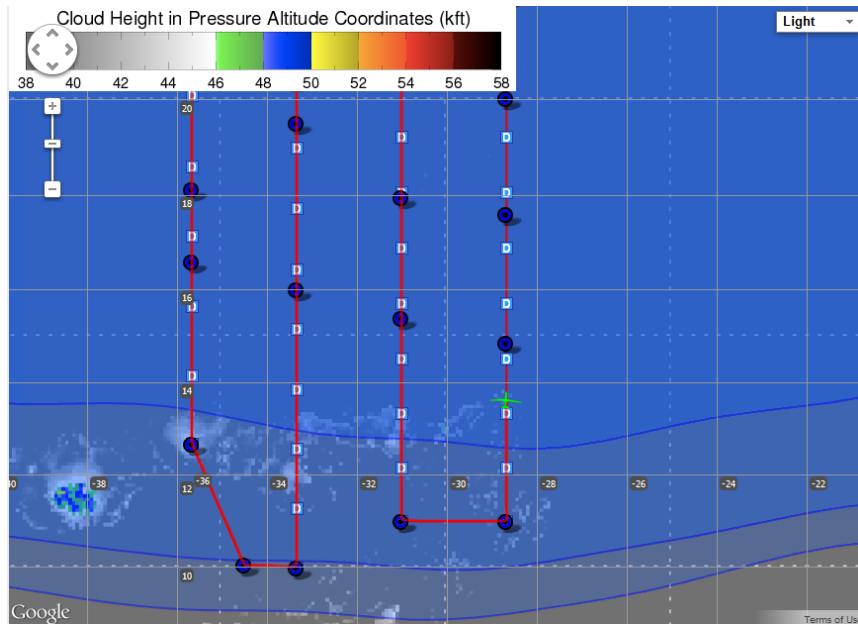


0136 Sonde 38. 12.29N/28.67W. Good data.

0140 If GEOS-5 is correct then the dust concentrations on this final eastern-most north-south leg should have the lesser dust concentrations.

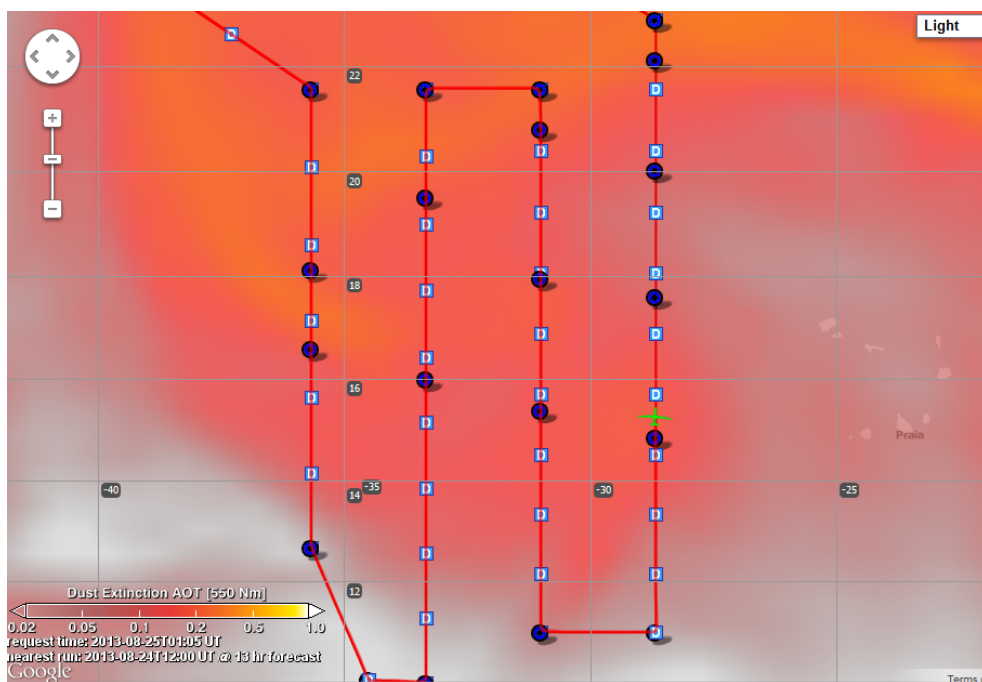
0148 Sonde 39. 13.50N/28.67W. Good data.

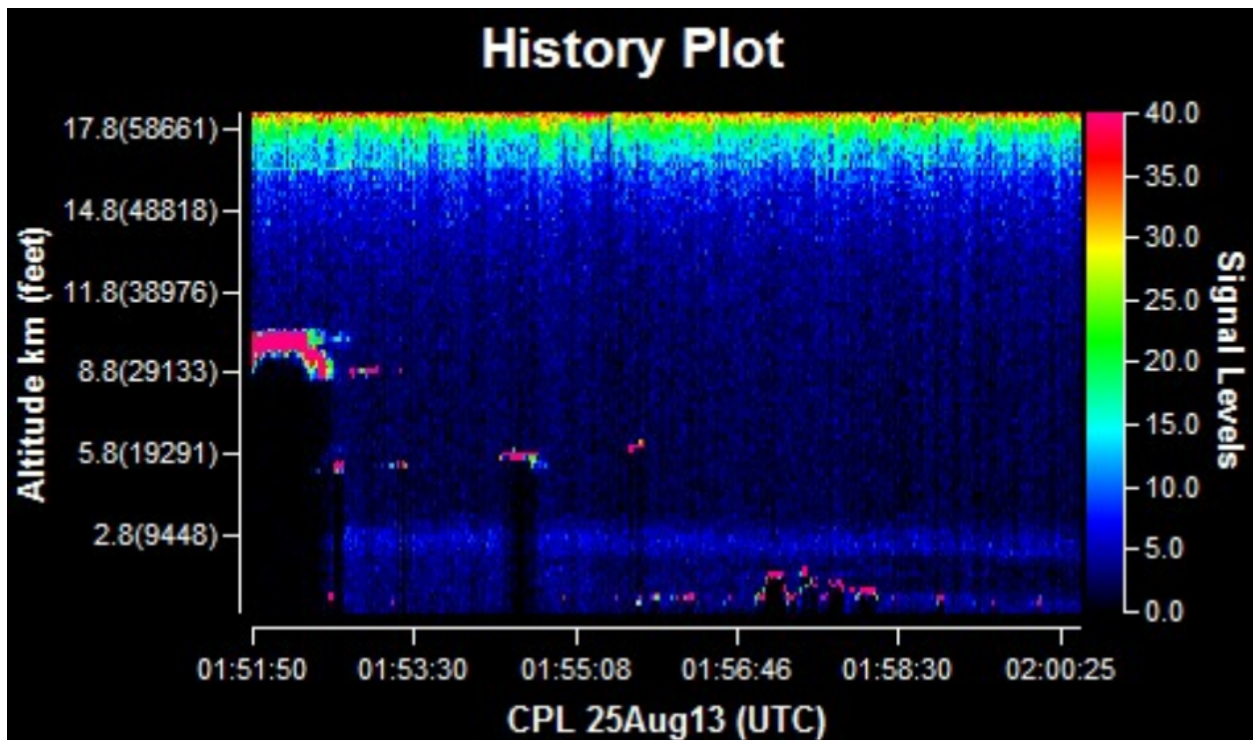
0150 Ku is back. Image below corresponds to return. The shading shows the expected Ku strength.



0200 Sonde 40. 14.53N/28.67W. Good data.

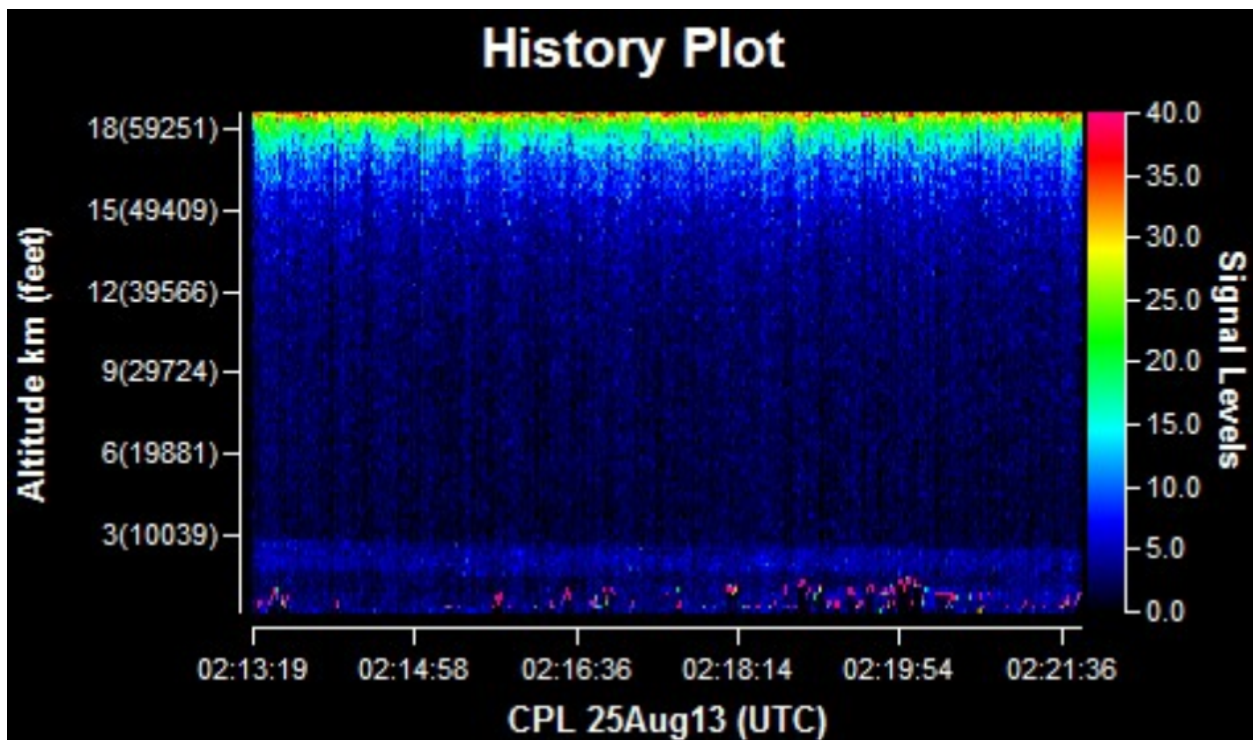
0205 CPL (image below with the corresponding forecast) shows the higher cloud tops that we crossed towards the turn point into this leg. Apparently the dust continues to be observed at 2.5 – 3km. As we progressed northward, there is apparently a decoupling from the surface layer as the scatter below that layer appears cleaner.





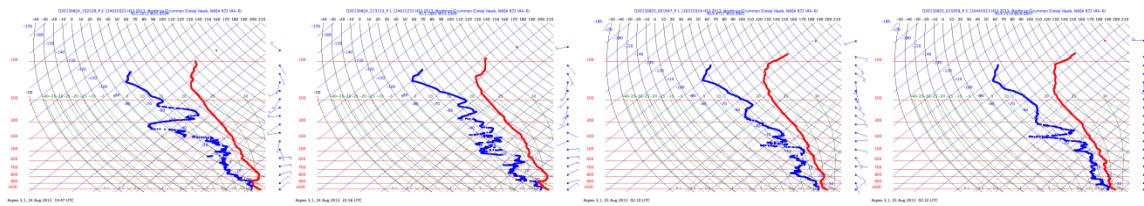
0212 Sonde 41. 15.71N/28.67W. Good data.

0220 The layer has thinned in the middle of the north-south leg, and the top even appears to have lowered slightly.



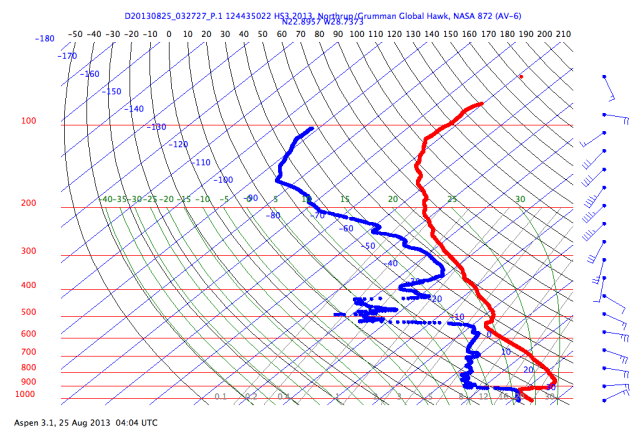
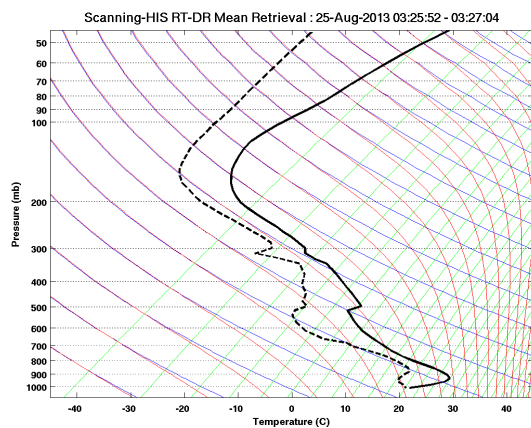
0224 Sonde 42. 16.94N/28.67W. Good data.

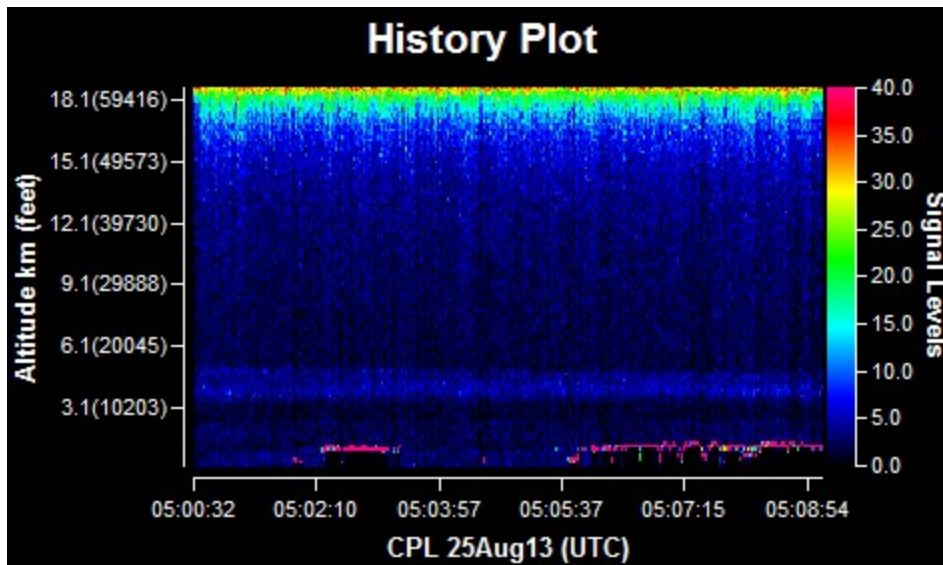
The trough axis appears to have been along the third leg (31 W):



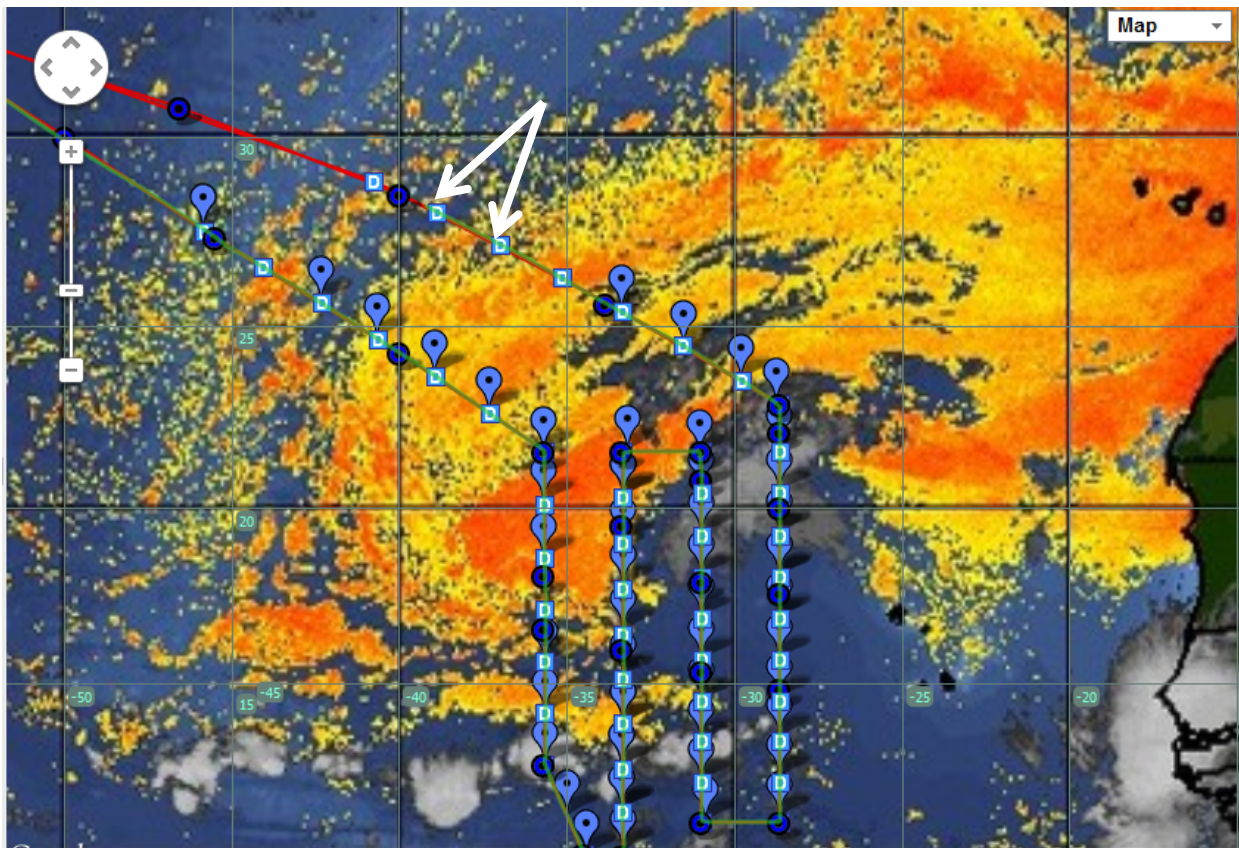
W-E Cross-section of dropsondes at 15.56 N, 35.66 W; 15.18 N, 33.33 W; 14.47 N, 31.00 W; 14.55 N, 28.66 W. The two western sondes have low-level NE'lies, inversions, and somewhat dry air. The third sonde in the trough axis has easterlies and more moisture. The eastern-most leg has SE'lies, much more moisture, and no inversion until about 17 N

Both AVAPS and SHIS are picking up a strong inversion in places, although not necessarily agreeing on the details. The images below are from the turn to the northwest at the end of the last S-N leg (22.89 N, 28.74 W).



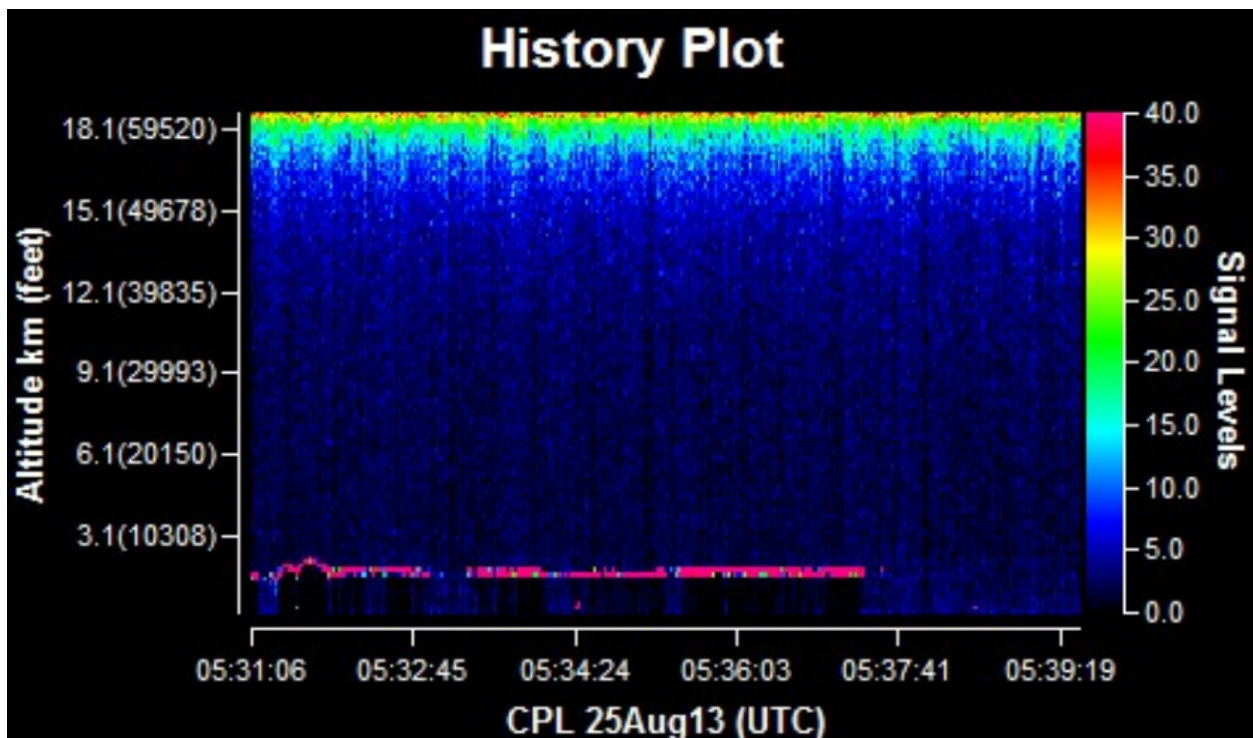
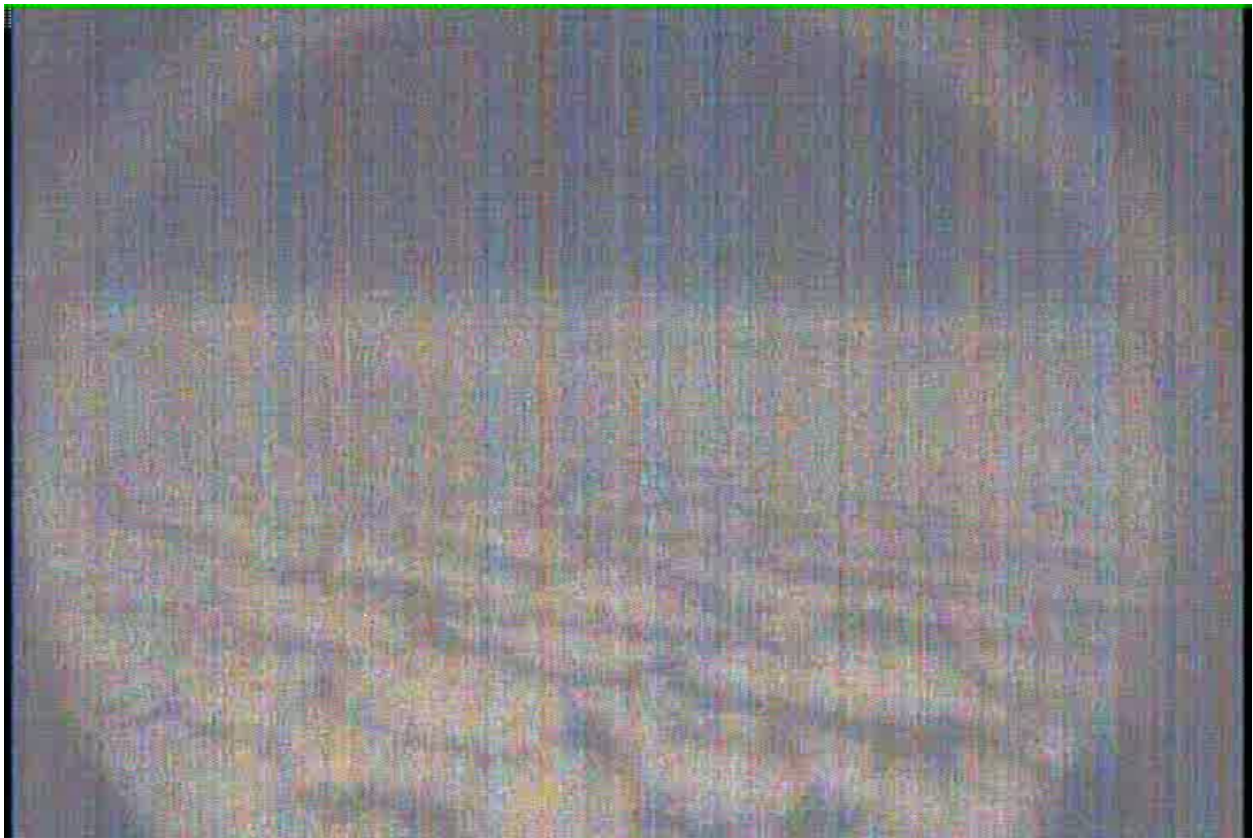


0512 This CPL image shows what appear to be two layers of dust/SAL. A higher concentration layer appears at around 5 km altitude and a lower concentration centered around 2 km altitude. The CPL image above was taken roughly along the white arrows illustrated below. A prominent SAL swath is evident from the CIMMS imagery with some intermittent low to mid-level clouds attenuating the CPL signal.

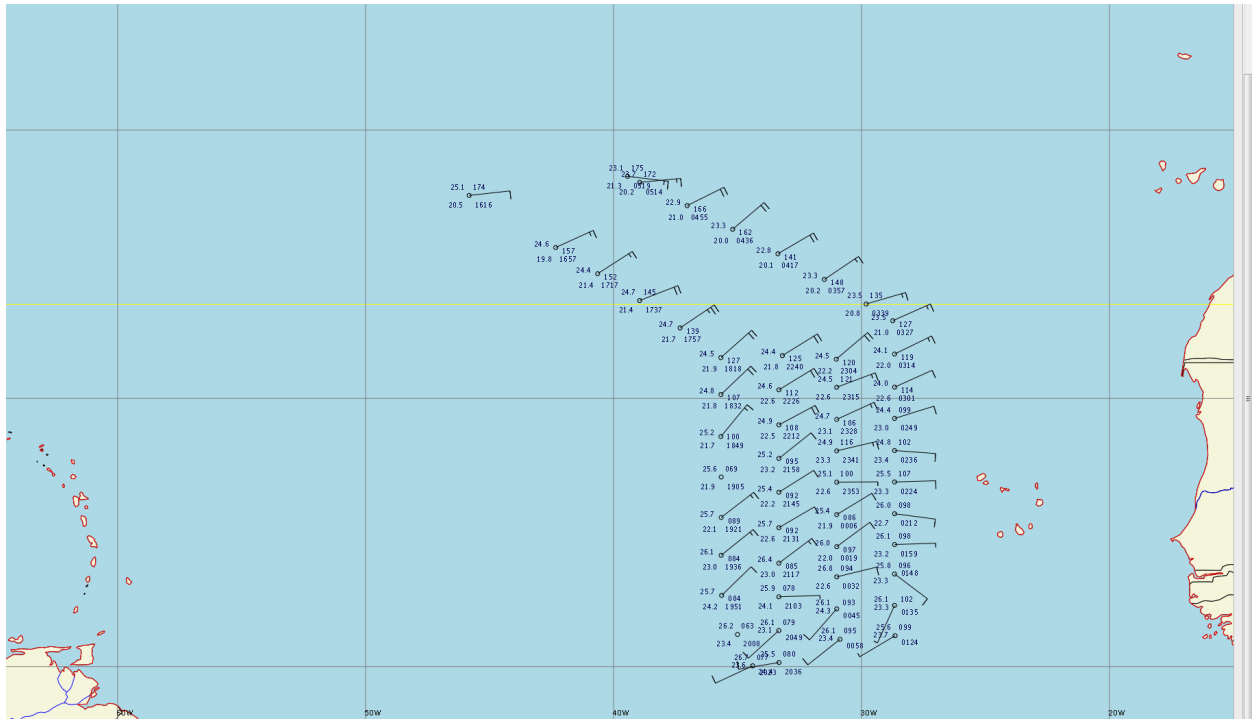


Updated landing time of 0800 EDT

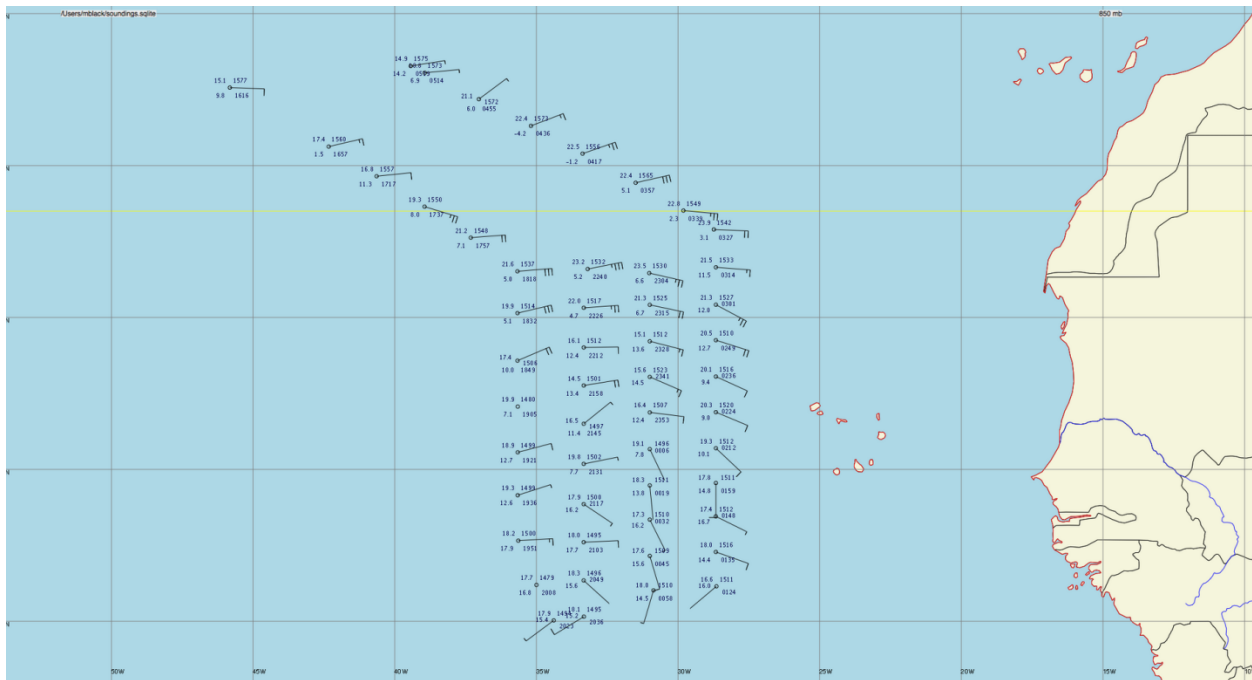
0540 Low light camera view from AV-6 showing a deck of stratocumulus clouds as we are exiting the SAL region on our way back home. The CPL image below this shows a slight indication of dust/SAL and the stratocumulus deck. The CIMMS SAL product and CPL match up fairly good.



0615 Current synoptic map of dropsonde winds at 1000 mb. Signature of monsoon trough occurring on the southern side of the pattern.



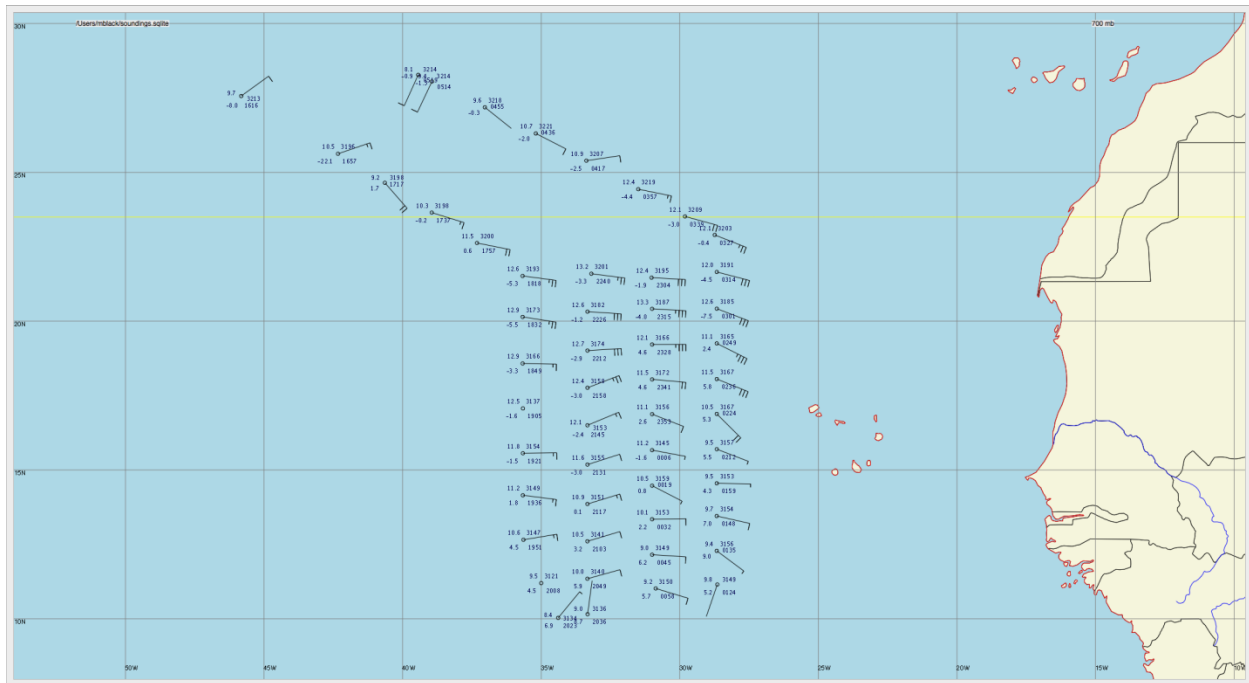
0623 Current synoptic map of winds at 850 mb. Similar structure to that seen at 1000 mb.



## Synoptic overview:

The above sonde maps, including the surface (not shown) illustrate the low level structure of P24L. A low-level trough extends ENE across the domain from a weak closed circulation with Pmin of 1006.3 located at 11N, 35W. A broad region of surface ENE winds at 15-20 kt extends across the remainder of the domain from 19 – 29N. A narrow easterly jet of 30-35 kt appears at 850 mb between 20-22N, which shows up more prominently at 700 mb (shown below) over the eastern half of the domain from 15-22N. This is an excellent representation of the African easterly jet located along the southern boundary of the SAL, which is well depicted in the CPL profiles.

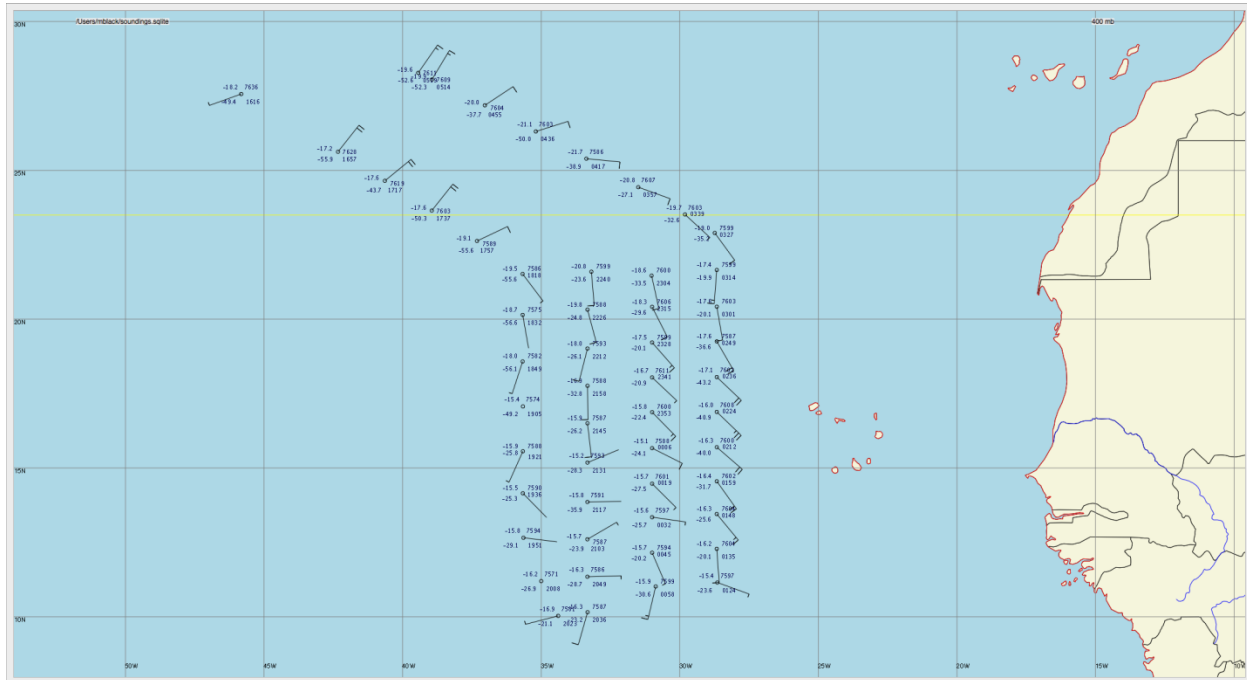
## 700 mb wind barbs.



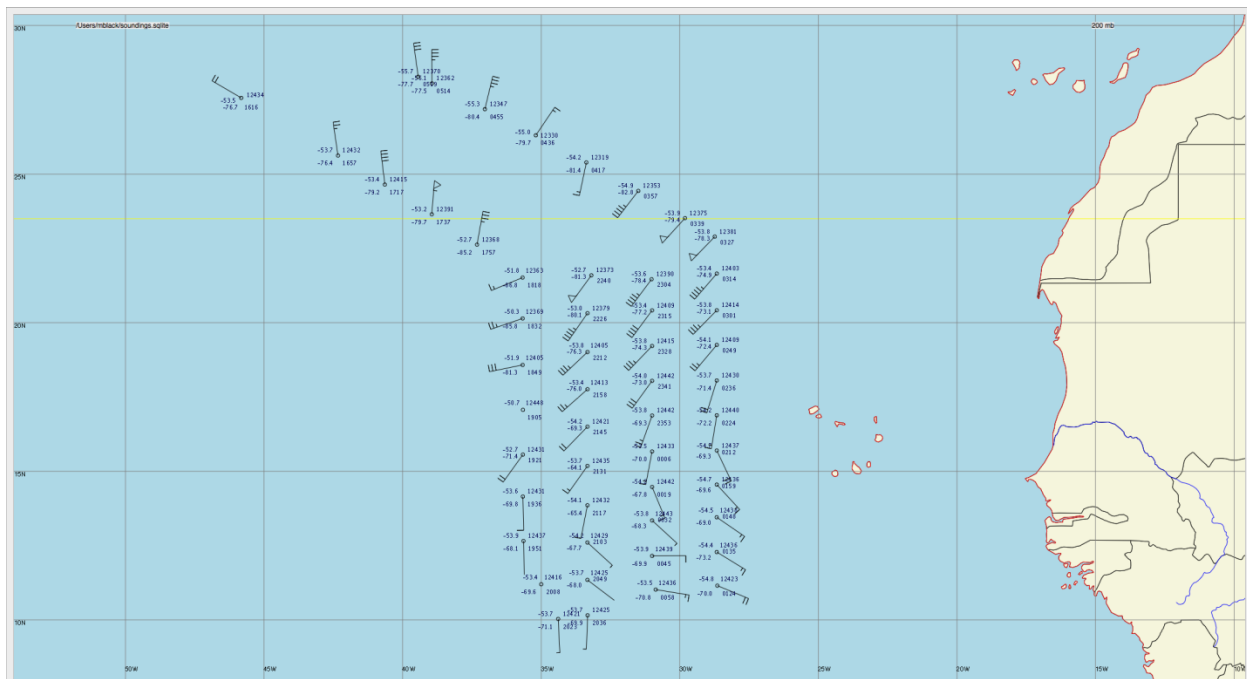
A dramatic change in the synoptic pattern over the domain takes place in the upper levels from 400-150 mb (also shown below) over the main SAL region. A prominent upper cold low extends from 400 mb to 150, tilting NE with increasing height from 21N, 37W to 23.5N, 35.5W. This feature was a max at 200 mb with a 50 kt southwesterly jet superimposed over the 700 mb 35 kt easterly jet producing a westerly shear over this layer on the order of 70-80 kt.

The schematic view of the major features in 24L is thus one of a weak low level circulation in the SW corner of the domain at 11N, 35W with the trough associated with the ITCZ extending ENE across the southern boundary of the domain. At mid-levels from 850-700 mb the African Easterly Jet on order 35 kt is well resolved at the southern boundary of the SAL in the middle of the domain. Superimposed on this pattern at high levels from 400-150 mb is an upper cold low centered at 21N, 37W that extends northeastward across the northern segment of the domain, with a prominent southwesterly jet of 50 kt extending above the mid-level SAL air. This is a textbook case of SAL structure in mid and low levels but

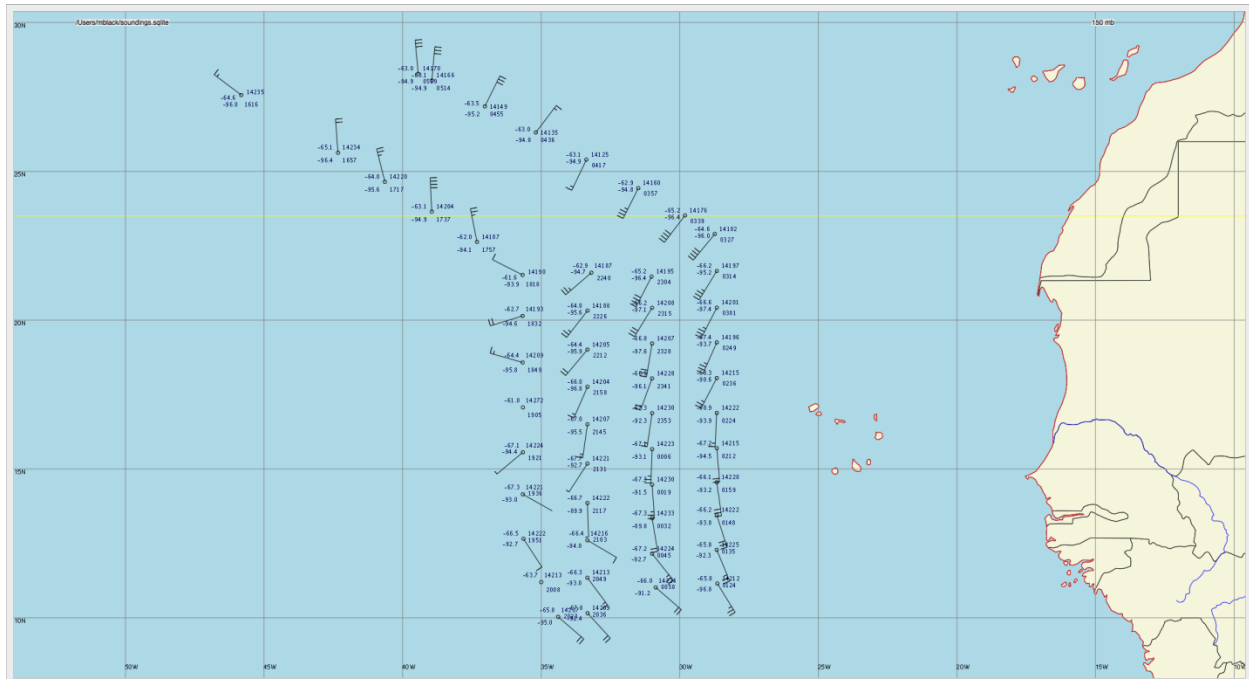
400 mb wind barbs:



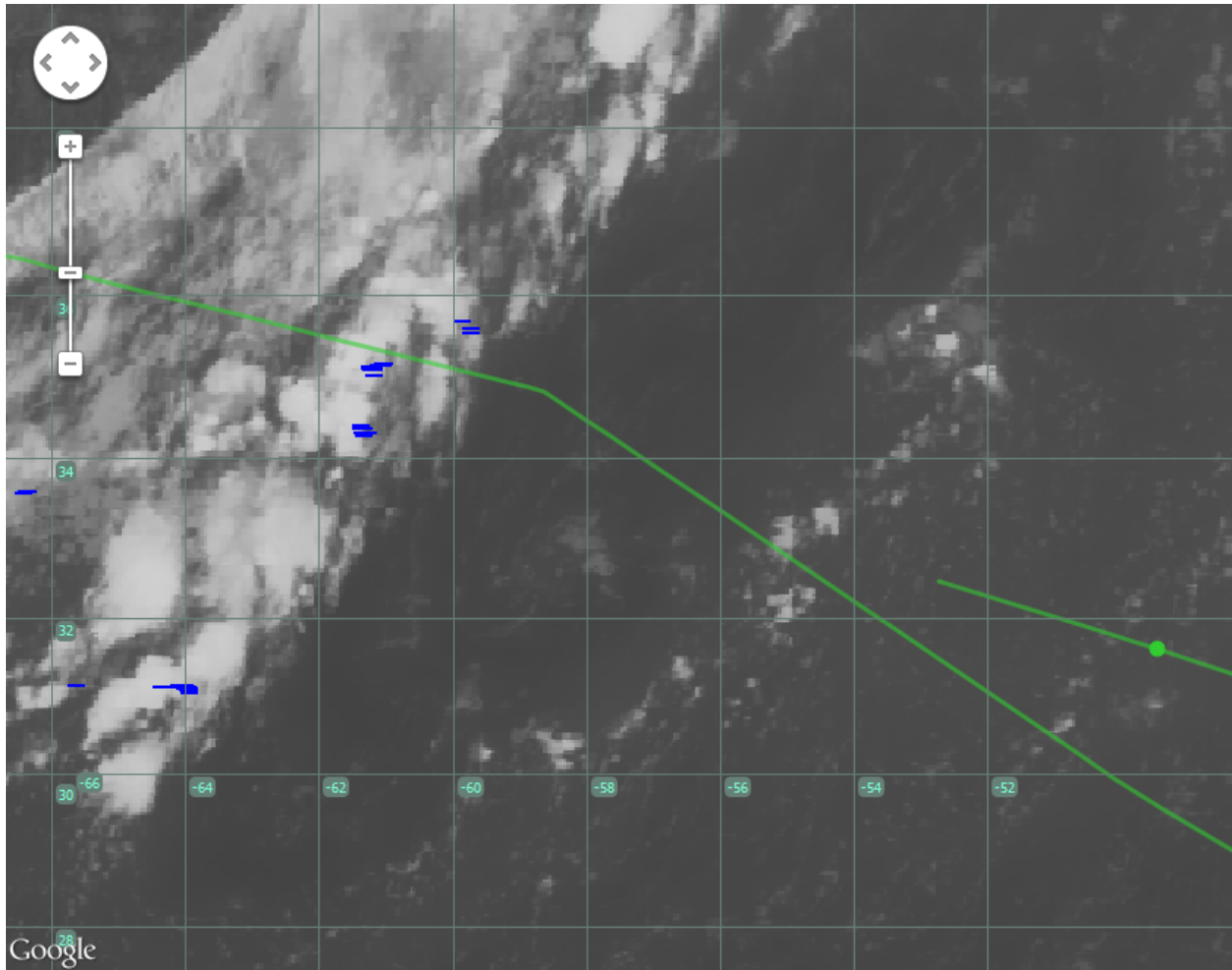
200 mb wind barbs:



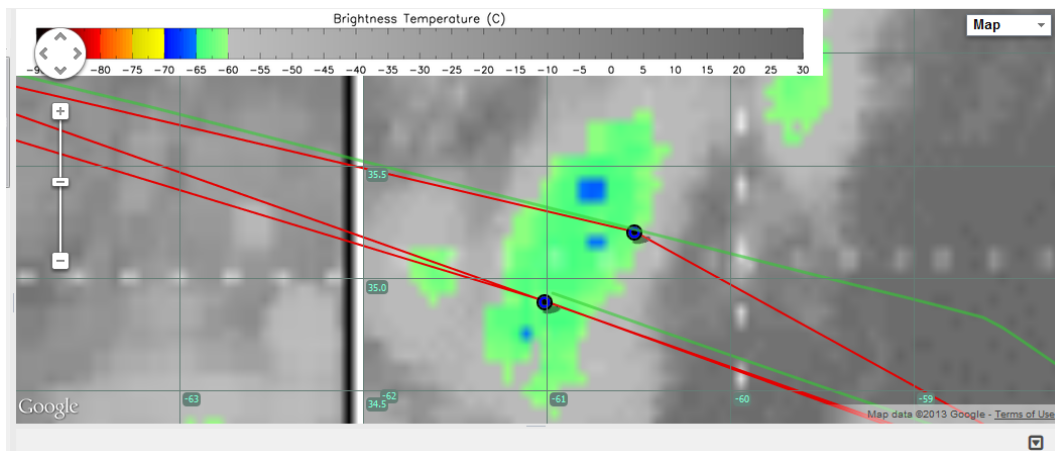
150 mb wind barbs:



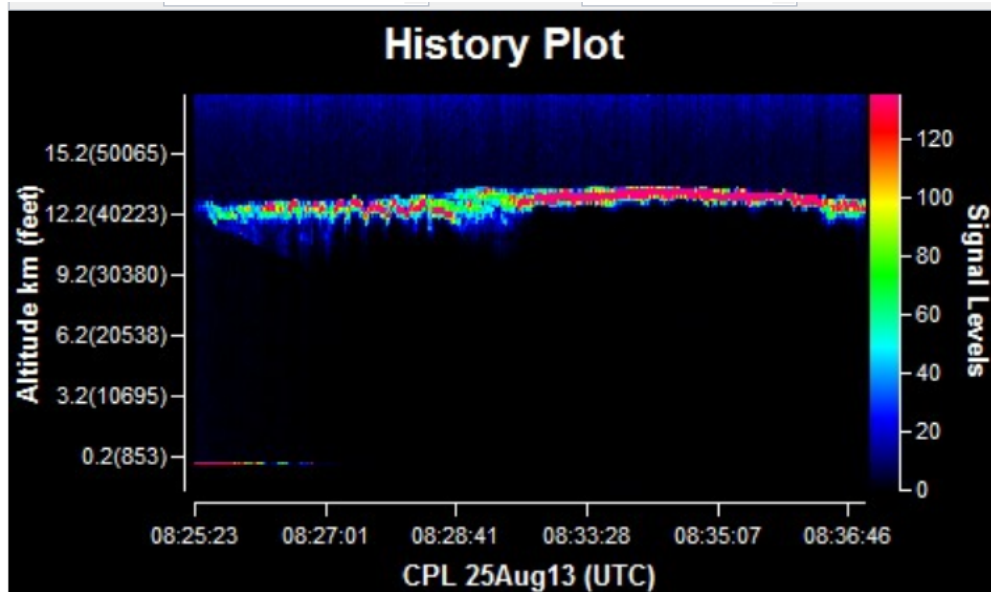
0717 There are a few flashes of lightning associated with a large frontal system that we are monitoring. The cloud top heights are much less than 50 thousand feet and the lightning is not significant. We will continue to monitor this and possibly let the mission director know.



At ~0835 UT, the plane flew over convection in a frontal system. Plane symbol is not showing in picture



At 0839 UT, CPL shows a domed thunderstorm cloud top up to around 44kft.



AV-6 low-light, hires nose camera feed to MTS was finally established as shown below during return leg NW of frontal boundary at 0945 UTC, 25 Aug:



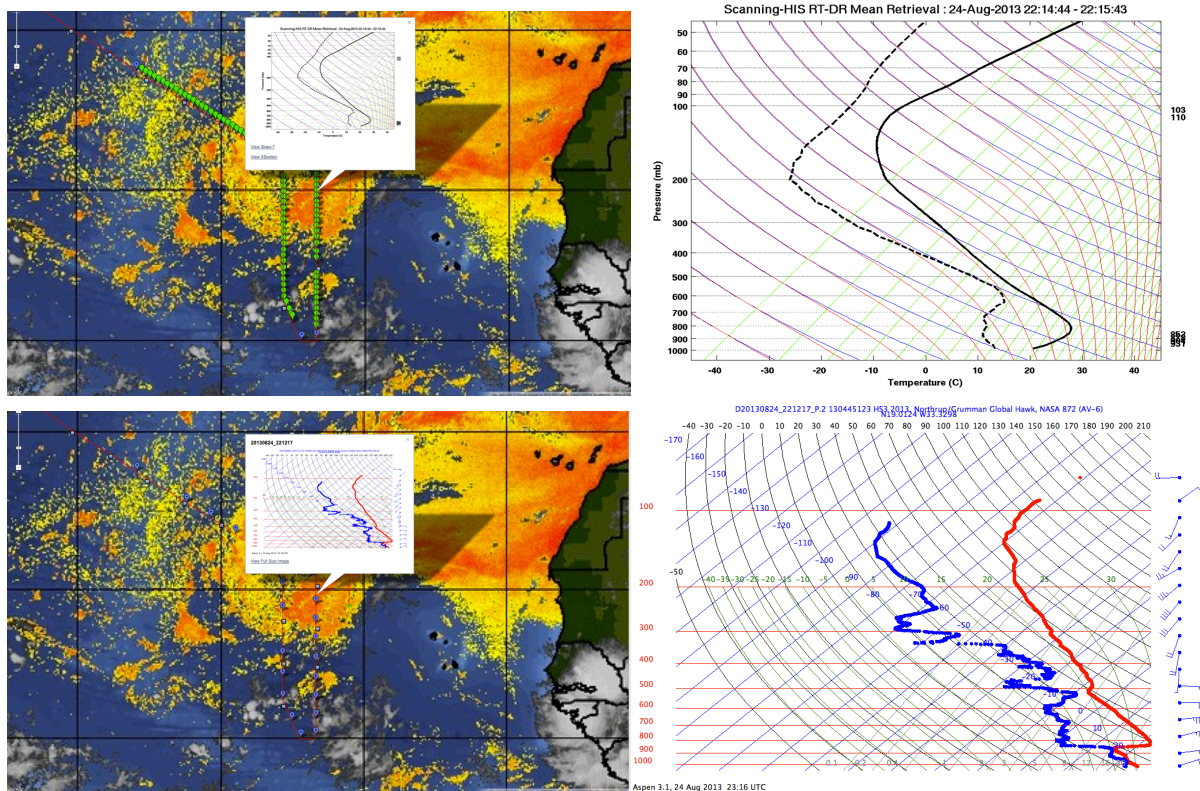
Instrument summaries.

## S-HIS

Nominal operation. No problems encountered. Ku lost in southernmost flight legs however complete SHIS data will be available in post-processed products. New “Half-Hour Summary” cross-section plots available on MTS under aircraft payload.

This was an excellent SAL flight with validation data from AVAPS dropsondes and CPL lidar with exciting dust “jet” cross-sections. Example quicklooks provided below illustrate that the S-HIS T/WV retrievals are capturing the moistening near the top of the dust layer (about 600 mb) validated by the dropsondes.

### SAL Region Sounding Comparison SHIS and Dropsonde: 20130824 22:12:17 UTC



## AVAPS

AVAPS performed extremely well throughout the flight of August 24-25. All 54 of the sondes loaded were successfully deployed. We experienced 2 fast falls which prevented measurement of accurate winds, but otherwise telemetry remained good and we were able to recover data all the way to the surface for each sonde. The data quality appeared very good and suggested a rich data set with extremely strong inversions in the SAL and interesting flow variations throughout



